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Understanding of resilience in the context of regional development using composite index approach: the case of European Union NUTS-2 regions

Michaela Stanickova[a] and Lukáš Melecký [b]

ABSTRACT

Economies have always been prone to different kinds of exogenous shocks, which can destabilize the path and pattern of regional economic growth. Regional economy perturbed by a shock may move onto a new growth path by re-establishing economic linkages, both internally and with other regions. The question why one region is more vulnerable to economic shock than other, impelled to analyze notion of resilience in a regional development context. Despite own limitations of quantitative methods, several approaches in the form of composite indices (CIs) have been proposed by the European Union (EU) and the other institutions. The aim of this paper is to throw light on some of the underlying aspects of regional resilience and provide an overview of a notion as well as analysis of research studies on constructing the territorial CIs. The main results of the paper are overview and comparison of regional resilience literature and empirics of existing CIs that lead to measuring the EU NUTS-2 regions resilience based on constructing own index. CIs construction includes several steps that have to be made and corresponding methods have to be chosen. Primarily, selection of sub-indicators, normalizing methods, weighting schemes and aggregation formulas are fundamental.

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INTRODUCTION

The territory has only recently become a terrain of strenuous economic research. With the New Economic Geography integrating into the mainstream, many spatial subjects, including territorial, or regional, competitiveness, are being increasingly the subjects of enquiry. In line with Krugman (2003), it is plausible to discuss competitiveness at a regional level, as the capacity of territories to attract and retain mobile factors of production, which is an increasingly important subject in an ever integrating global economy. However, this branch of economic geography is relatively underdeveloped; it even lacks a universally accepted definition and metrics. Over the last decades, regional competitiveness has been investigated deeply and these studies reveal

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that all the regions are not equally able to face the challenges that the new competition (affected by changes in the international environment) proposes. However, they fail at supplying both an exhaustive explanation and a pertinent, accessible and transferable measure of it. Understood in a more comprehensive way – as including both productivity and prosperity – it can be seen as a means to create favourable business conditions for companies and to increase the standards of living of the population. Supporting competitiveness, especially in the case of nations and regions, requires creating framework conditions to develop the necessary infrastructure, human capital, technology and efficient markets that can help to attract talent and investment. Being competitive also means having sufficient prerequisites for being able to withstand unexpected external shocks, i.e., the ability of a regional economy to withstand, absorb or overcome an internal or external economic shock. It is worth noting that resilience to an economic shock does not necessarily imply that the economy is otherwise strong and performing well over the longer term. Resilience has been a topic of growing interest as economic development practitioners have sought to understand the factors that affect the ability of an area to withstand and respond to economic shocks. While there are clear signs of economic recovery, evidence suggests that recent growth has been unbalanced. This, combined with the well-documented impact of the economic crisis, highlights the importance of ensuring that local economies continue to address structural issues and increase their resilience. Globalization, rapid technological change, deep recessions and man-made disasters have generated interest in regional economic resilience as an important field of study. The economic impact of these exogenous shocks and recovery mechanisms differ from region to region. Lack of economic diversification is one of the major weaknesses that limit the ability of a region to absorb an external shock, which confirms the close interdependence of competitiveness and resilience concepts.

Therefore, over the past few years, a new buzzword has entered academic, political and public discourse: the notion of 'resilience' – a term invoked to describe how an entity or system responds to shocks and disturbances. The concept of resilience is routinely used in research in disciplines ranging from environmental research to materials science and engineering, ecology, psychology, sociology and economics; it is thus now invoked in diverse contexts, both as a perceived (and typically positive) attribute of an object, entity or system and, more normatively, as a desired feature that should somehow be promoted or fostered (Martin & Sunley, 2015). Given this rise and spread of resilience talk, it is not surprising that the notion should have found its way into economic geography and regional studies (Foster, 2006; Hill, Wial, & Wolman, 2008; Martin, 2012; Norris, Stevens, Pfefferbaum, Wyche, & Pfefferbaum, 2008; Rose, 2009). The concept of resilience is rather complicated and deep in content as well as quite complex for an assessment and measurement. There is still not one generally accepted methodology for how regional resilience should be measured, what its determinants are and how it links to patterns of long-run regional growth. Consequently, it leads to a certain misunderstanding and different variations in using of resilience concept and its analysis. Analysis of resilience may bring the important information about the key problematic issues in the region (and thus in the country), on the one hand, and its development potential, on the other. In recent years, after the 2007–09 period of economic crisis, the notion of resilience has been rapidly becoming a part of the conceptual and analytical object of regional economic studies in line with the ongoing importance of regions as an economic subject and subject of decision-making processes in public policies.

The main purpose of this paper is to identify the specific aspects of resilience used in the regional development context and to suggest the tool for measuring the resilience in a European context. Its main focus is to introduce the construction of a specific composite weighted index and to verify this approach through brief empirical analysis and the evaluation of indicators that reflect the level of resilience in EU-28 NUTS-2 regions (NUTS is Nomenclature of Territorial Units for Statistics). For this purpose, the paper will determine and compute factors of regional resilience and propose a construction of composite weighted index of regional resilience

(CWIRR) for EU-28 NUTS-2 regions. The paper's hypothesis is based on the general concept of regional competitiveness (presented, for example, by Meyer-Stamer, 2008; Bristow, 2005; or Gardiner, Martin, & Tyler, 2004), where regions with a lower level of productivity and the ability to create and maintain the environment that sustains more value creation for their enterprises and more prosperity for their people achieve a lower level of resilience in the territory that provides worse conditions and assumptions for regional development potential, and vice versa.

CONCEPT OF REGIONAL RESILIENCE

Economic shocks occur periodically to economies, though the effect of these shocks varies from region to region, as does each region's adjustment and recovery. The authors are particularly concerned with regional resilience: why are some regional economies that are adversely affected by shocks able to recover in a relatively short period of time while others are not? Resilience is a concept that is frequently used in research in many disciplines, but is rarely well defined. If the idea of resilience is put meaningfully to work in regional policy agendas and practices, then it is necessary to have a clear definition, conceptualization and understanding of precisely what it is. Historically, the first definition of resilience can be found in the *Encyclopaedia Britannica* (1824). It is defined as the capability of a strained body to recover its size and shape after deformation caused especially by compressive stress or as the ability to recover from or adjust easily to misfortune or change. Resilience has roots in the Latin word *resilio/resilire*, meaning to jump back (Klein, Nicholls, & Thomalla, 2003). The notion of resilience is broadly defined as a return to an original state. There is no universally agreed definition of regional economic resilience; different authors employ different definitions and descriptions. For more information, see Table 1, which also contains a systematic literature review of this concept.

Most of the works refer to resilience as the ability of any system to recover from an external shock or to absorb against downturns (Briguglio, Cordina, Farrugia, & Vella, 2006; Brock, Maler, & Perrings, 2002; Rose & Krausmann, 2013). Thereby, resilience includes the ability to deal with external factors and reduce vulnerability, and one of its main tasks is to minimize losses and as a result to ensure the economic recovery in the shortest term. It is seen as a property that is present (or absent) on a continuous basis and is about engaging and coping with change in general. Adaptation, on the other hand, is more episodic, i.e., handling a particular shock or disturbance. The difference between an actual process, on the one hand (adaptation), and an underlying capacity, on the other (resilience), is crucial, as the former can be observed from the alterations that take place, whereas the latter cannot and can only be inferred from studying actual adaptation processes and then analyzing the underlying factors that are important for a successful adaptation. The notion of resilience is commonly used to denote both strength and flexibility. Conceptually, there are two separate, though not necessarily unrelated, concepts. The first is based on 'equilibrium analysis' in which resilience is the ability to return to a pre-existing state in a single-equilibrium system. The second defines resilience in terms of complex adaptive systems and relates to the ability of a system to adapt and change in response to stresses and strains (Pindus, Weir, Wial, & Wolman, 2012). For regional economic analysis, perhaps the most natural conceptual meaning of economic resilience is the ability of a regional economy to maintain or return to a pre-existing state (typically assumed to be an equilibrium state) in the presence of some type of exogenous shock. Although only a few studies explicitly use the term 'resilience', the economic literature that deals with the idea of resilience is typically concerned with the extent to which a regional or national economy can return to its previous level and/or growth rate of output, employment or population after experiencing an external shock (Feyrer, Sacerdote, & Stern, 2007; Briguglio et al., 2006; Rose & Liao, 2005; Blanchard & Katz, 1992). Based on Martin (2012), regional resilience is a multidimensional property involving four interrelated dimensions describing respond to shock: resistance, recovery, reorientation and renewal.

Table 1. Literature review of the resilience concept.

Year	Authors	Understanding the resilience concept
2015	Martin and Sunley	Resilience refers to a capacity to withstand or recover from the market, competitive and environmental shocks
2012	Martin	Capacity of the regional economy to reconfigure, i.e., adapt, its structure (firms, industries, technologies and institutions) so as to maintain an acceptable growth path in output, employment and wealth over time
2010	Gunderson et al.	Resilience concept does not necessarily imply a return to the pre-existing state but could be referred to as the capacity to respond to opportunities which arise as a result of the change
2009	Rose	Process by which a community develops and efficiently implements its capacity to absorb an initial shock through mitigation and to respond and adapt afterwards so as to maintain function and hasten recovery, as well as to be in a better position to reduce losses from future disasters
2008	Cutter et al.	Resilience is the ability of the social system to respond and recover from disasters and includes those inherent conditions that allow the system to absorb impacts and cope with an event, as well as post-event, adaptive processes that facilitate the ability of the social system to reorganize, change and learn in response to a threat
2008	Hill et al.	Ability of the regional economy to maintain a pre-existing state in the presence of some type of exogenous shock; the extent to which a regional or national economy that has experienced an external shock can return to its previous level and/or growth rate of output, employment or population
2008	Norris et al.	Process linking a set of adaptive capacities to a positive trajectory of functioning and adaptation after a disturbance
2006	Foster	Ability of the region to prevent, prepare, respond and 'recover' after a disturbance so as not to stand this obstacle to its development
2006	Perrings	Ability of the system to withstand either market or environmental shocks without losing the capacity to allocate resources efficiently
2004	Coles et al.	Community's capacities, skills and knowledge that allow it to participate fully in recovery from disasters
2004	Walker	Capacity of a system to absorb disturbance and reorganize while undergoing a change so as to still retain essentially the same function, structure, identity and feedbacks
2003	Bruneau et al.	Ability of the system to reduce the chances of shock, to absorb shock if it occurs (abrupt reduction of performance) and to recover quickly after a shock (re-establish normal performance)
2001	Carpenter et al.	Adaptive capacity that allows for continuous development, such as a dynamic interplay between sustaining and developing with change
1997	Reich	Structure of relationships among macroeconomic variables that persists over a long period of time and the economic, political and social institutions that condition this structure
1973	Holling	Amount of disturbance that the ecosystem could withstand without changing self-organized processes and structures, defined as alternative stable states, i.e., a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables
1958	Elton	Resilience as the amplitude of changes brought about by both disturbance and dynamics of post-disturbance recovery

Sources: Authors' own elaboration; Stanickova (2017a).

Opinions vary about the definition of resilience, and there is no mainstream approach to the measurement and expression of resilience and, therefore, no uniform strategies for strengthening the resilience of economies. Quantifying systems and regional resilience is a complex process, and scales for measuring resilience, at any level, do not currently exist. What helps build or shape resilience? The structural factors shaping resilience might usefully be labelled as the 'inherent' components of resilience in social systems, i.e., the factors that shape innate capacities to react, or the autonomous responses to shocks (Rose, 2004). In economics, for example, such mechanisms might include automatic fiscal stabilizers and the ability of markets to reallocate resources or substitute inputs in response to price signals. Building on complex adaptive systems thinking, these inherent components relate to the system's capacities to self-organize. The emerging empirical evidence suggests that one set of inherent factors shaping regional resilience to economic shocks is their initial strengths and weaknesses (Huggins, Izushi, Davies, & Shougui, 2010). This seems to affirm the theoretical assertions from evolutionary economic geography that regional resilience is likely to be path dependent and shaped by a region's industrial legacy, the nature of its pre-existing economy (principally, what is happening to the product and profit cycles of its key aspects, particularly export, industries), and the scope for reorientating skills, resources and technologies inherited from that legacy (Boschma & Martin, 2010; Simmie & Martin, 2010). In a study of the impact of the post-2008 financial crisis and recession on several European regions, Huggins et al. (2010) found that factors, such as the size of the market, access to a larger external market as well as endowments in natural resources and in physical and human capital, play an important role in shaping variable impacts. Another critical structural or inherent dimension appears to be the sectoral structure of regions. In general terms, a region's vulnerability to adverse economic shocks is correlated with its sectoral specialization, although the degree of regional specialization has decreased in Europe since the 1950s, not least due to the growth of public services and some private services in all regions (Huggins et al., 2010). Again, this appears to support theorizing drawing on the evolutionary conception of resilience, which has highlighted the merits of 'species diversity' for regional economies (Bristow, 2010). Diversity is deemed essential in complex adaptive systems, both in terms of absorbing disturbance and in regenerating and reorganizing the system following the disturbance (Levin et al., 1998). Studies suggest that regions that specialize in a narrow range of sectors are particularly vulnerable to sectoral shocks and run the risk of suffering permanent reductions in the numbers of firms and jobs (Huggins et al., 2010) or negative hysteretic effects (Martin, 2012). A more diverse economic structure provides greater regional resistance to shocks than does a more specialized structure, since the risk is effectively spread across a region's business portfolio, although a high degree of sectoral interrelatedness may limit this (Martin, 2012), as stated in the European Observation Network for Territorial Development and Cohesion's (ESPON) report on *Economic Crisis: Resilience of Regions* (2014, pp. 35–36).

Following the research studies below, indicators and subsequently factors of regional resilience are designed, they are considered crucial for the purposes of this paper. We do not want just to use previously defined factors, but desire to find relevant indicators that could be part of factors crucial for one's own index. But what are the main characteristics of regional resilience? Here is the issue of what determines the resilience of regional economy: what is it that makes the regional economy more or less resilient? Research describing the patterns and determinants of shock resistance and/or economic resilience is sparse. Based on the scientific literature, there are specific factors that affect a region's abilities to be resilient. Each factor is different in each region and changes over time. The regional literature points out several features of regions that may contribute to either shock resistance or resilience. The first group of factors is suggested by Martin (2012) and among the key factors of regional resilience ranks: the dynamic growth of the region, the structure of the economy, the export orientation and specialization of the region, human capital, the innovation rate, the business and corporate culture, the localization of the

region, and the institutional arrangement in the region. The second group of factors is defined by Foster (2006) and among the key factors of regional resilience are regional economic capacity, the sociodemographic capacity of the region and regional community's capacity. To capture the effects of shock absorption or shock-counteraction policies across countries, Briguglio, Cordina, Farrugia, and Vela (2009) proposed the four components (and their related indicators) of a resilience index, i.e., macroeconomic stability, microeconomic market efficiency, good governance and social development. In the Czech Republic, Koutský, Rumpel, and Slach (2012) engage issues of regional resilience determinants and define factors: the main macroeconomic indicators, labour market indicators etc. We have also reviewed 50 publications (new or relatively new works published in the period 2005–16) to discover the relevant indicators associated with the construction of the CWIRR (for more information, see Stanickova, 2017b). Given the absence of a unified approach to assessing the European Union's (EU) resilience, we have decided to develop our own regional resilience index covering all possible aspects of this concept (based on the availability of data).

Based on these sets of factors of regional resilience outlined above, we define (with a certain degree of generalization) a set of indicators for resilience that are also important in terms of competitiveness (based on a common relation). In this paper we link the concepts of resilience with competitiveness. It is very important to understand the extent to which areas (such as regions) compete with each other, where this competition comes from and what factors determine territorial economic attractiveness. A territorial competitiveness approach plays a key role from the perspective of an appropriate database of indicators for the design of the CWIRR. To improve the understanding of territorial competitiveness at the regional level, the European Commission has developed the regional competitiveness index (RCI), which shows the strengths and weaknesses of each of the EU's NUTS-2 regions and, therefore, provides a guide to what each region should focus on, taking into account its specific situation and its overall level of development. For more details about RCI design, see Annoni, Dijkstra, and Gargano (2017), Annoni and Dijkstra (2013), and Annoni and Kozovska (2010). The basic approach for choosing relevant indicators is, thus, the RCI. The indicators used in the framework for 'flagship' areas of resilience with a link to competitiveness are as follows: government effectiveness (GE), corruption (C), rule of law (RL), motorway potential accessibility (MPA), railway potential accessibility (RPA), healthy life expectancy (HLE), cancer disease death rate (CDDR), heart disease death rate (HDDR), population aged 25–64 years with a higher education (PE), lifelong learning (LL), accessibility to universities (AU), employment rate (ER), long-term unemployment rate (LTUR), labour productivity (LP), disposable income (DI), gross domestic product (GDP), employment in sophisticated (K-N) sectors (ESS), gross valued added of sophisticated (K-N) sectors (GVA), total patent applications (TPA), core creative class employment (CCCE), gross expenditure on research and development (GERD), human resources in science and technology (HRST), high-tech patents (HTP), and information and communication technology patents (ICTP). However, selected indicators are considered as the initial research. Resilience is certainly influenced by the nature state economic policy, the export orientation of regions and other factors.

One way to assess regional resilience is by its qualities to cope with future challenges. The resilience index is intended to measure the effect of shock absorption or shock-counteraction policies across evaluated territories. The index can be effectively used to communicate to relevant stakeholders the importance of resilience-building and thereby act as an effective focal point in policy-making (in all areas of political activities) by using an integrated approach to improve the components in Stanickova (2017b), who reviews the relevant indicators to the construction of the CWIRR. It is, however, important to note that the effectiveness of the index is dependent on the 'appropriate coverage, simplicity, ease of comprehension affordability, suitability for international comparisons and transparency' of its components (Briguglio et al., 2009, p. 234). The question of considering for evaluation regional resilience is the inclusion of indicators based

on the literature review. There is a fundamental division in the literature dealing with indicators and there are those who choose to aggregate variables into a composite index (or indicator) and those who do not. This decision, in effect, divides the indicators research community into two groups (Sharpe, 2004). The aggregators believe that for two major reasons there is a value that combines indicators in some manner to produce a bottom line. First, they believe such a summary statistic can, indeed, capture reality and its meaningfulness. Second, they stress that bottom lines are extremely useful in garnering media interest and, hence, the attention of policy-makers. The non-aggregators believe one should stop once an appropriate set of indicators has been created and not go the further step of producing a composite index. Their key objection to aggregation is what they see as the arbitrary nature of the weighting process by which the variables are combined.

The selection of indicators is based on the perception of the developers of what constitute the key variables of a domain. A major consideration is the availability of time-series and/or cross-section data. The empirical representation must be given to any ideal indicator if an index or set of indicators is to be developed to assess trends in resilience over time or across space. A number of frameworks can be adopted for indicator selection. Frameworks have also been developed for the evaluation of indicators, although a full discussion of these frameworks is beyond the scope of this paper. The appropriateness of a particular framework is in the eye of the potential user. It depends on what the framework was designed to do, whether it is to assess trends, to serve as a tool for policy-makers to evaluate policies and programmes or to be used as a rallying point for advocacy groups with a certain agenda. For example, a committee of the International Society for Quality of Life Studies has proposed six criteria for the evaluation of indices and six criteria for the evaluation of the domains covered by indices (Hagerty et al., 2001):

- To have a clear practical purpose and that such purposes include usefulness for public policy and the measurement of trends and the levels of economic and social well-being (it can be considered an umbrella framework including resilience issues).
- To be well grounded in well-established theory, defined as a set of concepts and causal paths that specify how well-being is related to exogenous and endogenous indicators; 'well-established' means that the theory has been subjected to an empirical test.
- To be reported as a single number but capable of being broken down into components as a single number allows citizens and policy-makers to assess whether overall well-being is improving.
- To be based on time-series data to allow monitoring, as this is crucial for public policy in order to assess whether conditions are improving for targeted populations and to forecast future conditions.
- To be reliable, valid and sensitive; thus, all well-being indicators must be based on indicators that can be measured in a statistically reliable and valid manner and must be sensitive in that they show some movement over time, particularly in response to influences such as public policy.
- To help policy-makers assess programmes and policies at various levels (e.g., individual, family/household, community, state/province, national and international).

As Sharpe (2004) stated, no existing framework currently includes all important concepts and linkages, and it is unlikely that one ever will. As the survey of the indicators literature reveals, the development of a framework for indicators involves choices related to the domains of interest, the purpose for which the composite index is designed. Choices or trade-offs have to be made and there must be a balance between conceptual sophistication and transparency and between complex linkages that potentially confuse the user and simplicity.

METHODOLOGY AND STRUCTURE OF THE CWIRR

A relatively independent and frequently used approach for the measurement and evaluation of competitiveness and resilience is the construction of comprehensively integrated indicators and composite indices. Composite indicators and indices (CIs), which compare territorial (e.g., country, region, city or local municipality) performance, are increasingly recognized as a useful tool in policy analysis and public communication and very common for benchmarking the mutual and relative progress of territories in a variety of policy domains. CIs as a tool for a ranking are becoming increasingly popular because they illustrate a comprehensive view of a phenomenon that cannot be captured by only a single indicator. They provide simple comparisons of territories that can be used to illustrate complex and elusive issues in wide-ranging fields, e.g., environmental, economic, societal or technological development. It often seems easier for the general public to interpret CIs than to identify common trends across many separate indicators, and they have also proven useful in benchmarking territorial performance. This reflects a growing recognition of the important role that CIs can play as a tool for evaluating trends in the level of economic, social and environmental development and for assessing the impact of policy on well-being. However, CIs can send misleading policy messages if poorly constructed or misinterpreted. In fact, they must be seen as a means of initiating discussion and stimulating public interest (Melecký, 2017; Melecký & Stanickova, 2015b). Therefore, CIs are useful in their ability to integrate large amounts of information into easily understood formats and are valued as a communication and political tool. They are often a compromise between scientific accuracy and the information available at a reasonable cost. However, CI construction suffers from many methodological difficulties, with the result that they can be misleading and easily manipulated. The main pros and cons of using CIs are provided in Table 2.

The literature on CIs is vast and almost every month new proposals are published on specific methodological aspects potentially relevant for their development. CIs are much like mathematical or computational models and, as such, their construction owes more to the craftsmanship of the modeller than to universally accepted scientific rules for encoding. With regard to models, the justification for a CI lies in its fitness for the intended purpose and in peer acceptance. The quality of a CI, as well as the soundness of the messages it conveys, depends not only on the methodology used in its construction but also primarily on the quality of the framework and the data used. A composite based on a weak theoretical background or on soft data containing large measurement errors can lead to disputable policy messages, in spite of the use of the state-of-the-art methodology in its construction. It is important to emphasize that the theoretical part (definition of the phenomenon and selection of the indicators) is not separate from the statistical–methodological part, so the choice of the individual indicators is not independent of the choice of the aggregation method. No universal method exists for the construction of CIs. In each case, their construction is much determined by the particular application, including both formal and heuristic elements, and the incorporation of some expert knowledge about the phenomenon. Nevertheless, the advantages of CIs are clear, and they can be summarized in the unidimensional measurement of the phenomenon, an easy interpretation with respect to a battery of many individual indicators and simplification of the data analysis (e.g., ranking units and comparing their performance over time). The main factors to take into account in the choice of the method to be adopted for summarizing individual indicators are as follows (Mazziotta & Pareto, 2013):

- Type of indicators (substitutable/non-substitutable).
- Type of aggregation (simple/complex).
- Type of comparisons (absolute/relative).
- Type of weights (objective/subjective).

Table 2. Pros and cons of composite indices (CIs).

Pros	Cons
Can summarize complex, multidimensional realities with a view to supporting decision-makers Provide the big picture. Can be easier to interpret than trying to find a trend in many separate indicators Facilitate the task of ranking countries on complex issues and can assess the progress of countries over time	May send misleading policy messages if poorly constructed or misinterpreted The simple 'big picture' results that CIs show may invite politicians to draw simplistic policy conclusions
Reduce the visible size of a set of indicators without dropping the underlying information base Can help to reduce the size of a list of indicators or to include more information within the existing size limit	May be misused, e.g., to support the desired policy, if the construction process is not transparent and/or lacks sound statistical or conceptual principles
Place issues of country performance and progress at the centre of the policy arena Facilitate communication with the general public and promote accountability	Construction of CIs involves stages where judgement has to be made: the selection of indicators, choice of model, weighing indicators and treatment of missing values etc., i.e., the subject of political dispute
Help to construct/underpin narratives for lay and literate audiences	May disguise serious failings in some dimensions and increase the difficulty of identifying the proper remedial action if the construction process is not transparent
Enable users to compare complex dimensions effectively	May lead to inappropriate policies if dimensions of performance, which are difficult to measure, are ignored

Sources: Saisana and Tarantola (2002); authors' own elaboration (Melecký, 2017).

There is not always a 'well-established' solution, and sometimes it may be necessary to renounce some requirements to satisfy others.

Society is changing quickly, therefore we need to know as soon as possible when things go wrong. This is where CIs enter the discussion. A CI is an aggregated indicator comprising individual indicators and weights that commonly represent the relative importance of each indicator. However, CI construction is not straightforward and the methodological challenges raise a series of technical issues that, if not addressed adequately, can lead to CIs being misinterpreted or manipulated. Therefore, careful attention needs to be paid to their construction and subsequent use. CI developers have to face a justifiable degree of scepticism from statisticians, economists and other groups of users. This scepticism is partially due to the lack of transparency of some existing indicators, especially as far as methodologies and basic data are concerned.

The number of CIs in existence around the world is growing every year. Bandura (2006) cites more than 160 CIs. They are very common in the field of economics and are used in a variety of policy domains such as national or regional competitiveness, sustainable development, quality-of-life assessment, globalization and innovation. This paper examines a number of published studies on this topic, which correspond to the concept of well-being. For each type of CI reviewed, general information about the number and type of indicators is offered (Table 3), and these will be used when measuring regional resilience based on the construction of the authors' own index. The importance of the CI approach for EU research is confirmed by the number of studies that evaluate the level of development in specific thematic topics across the EU's territory. Many more approaches evaluating the EU in terms of CIs exist, but they are not included in the evaluated sample with regard to their progress in terms of theory and empiricism, timeliness and validity, e.g., An Indicator for Measuring Regional Progress towards the Europe 2020 Targets (European

Table 3. Overview of the European Union's main composite indices.

Authors	Year	Publication	Territory	Indicators
Annoni and Kozovska (EC-DG JRC)	2010	*EU Regional Competitiveness Index 2010*	268 EU-27 NUTS-2 regions	RCI 2010 is composed of 69 indicators in 11 pillars: inputs (institutions, macroeconomic stability, infrastructure, health, quality of primary and secondary education, higher education/training and lifelong learning, technological readiness); outputs (labour market efficiency, market size, business sophistication and innovation)
Annoni and Dijkstra (EC-DG JRC)	2013	*EU Regional Competitiveness Index 2013*	262 EU-28 NUTS-2 regions	RCI 2013 has basically the same framework and structure of the 2010 edition. It is based on a set of 80 candidate indicators of which 73 have been eventually included in the index within the pillars
Annoni, Dijkstra and Gargano (EC-DG RUP)	2017	*EU Regional Competitiveness Index 2016*	263 EU-28 NUTS-2 regions	RCI 2016 has basically the same framework and structure of the 2010 and 2013 editions. The RCI 2016 index is based on 74 mostly regional indicators in the same pillars
Annoni, Dijkstra and Hellman (EC-DG RUP, Social Progress Imperative)	2016	*EU Regional Social Progress Index*	EU-28 member states (272 NUTS-2 regions)	Index is an aggregated index of 50 social and environmental indicators that capture three dimensions of social progress (basic human needs, foundations of well-being, and opportunity) and their underlying 12 components (nutrition and basic medical care, water and sanitation, shelter, personal safety, access to basic knowledge, access to information and communications, health and wellness, environmental quality, personal rights, personal freedom and choice, tolerance and inclusion, access to advanced education)
European Observation Network for Territorial Development and Cohesion (ESPON)	2014	*Economic Crisis: Resilience of Regions*	EU-27 member states, Iceland, Liechtenstein, Norway, Switzerland	Evaluation of regional resilience is based on two principal indicators: the number of persons employed and levels of economic output (gross domestic product – GDP)

Grunfelder, Rispling and Norlen (Nordregio)	2016	*Nordregio's New Regional Potential Index*	Denmark, Finland, Iceland, Norway, Sweden, Faroe Islands, Greenland, Åland	Criteria: regional potential, demographic potential, labour market potential, economic potential. Indicators: population density, net migration rate, demographic dependency rate, female ration, employment rate, share of the age group 25–64 with a high education degree, youth employment rate, GDP/capita, total research and development (R&D) investments
Domínguez-Torreiro (EC-DG JRC)	2016	*Developing Regional Inclusive Society Index in EU*	EU regional level	Dimensions for proposed indicators: income distribution and well-being, access to employment and good quality jobs, access to knowledge, access to health, social protection performance, social capital and governance, vertical social mobility, gender equality, non-discrimination and tolerance, personal security
European Commission – DG RUP	2014	*Regional Entrepreneurship Development Index*	125 regions of 24 EU member states	Index consists of three sub-indices (entrepreneurial attitudes, entrepreneurial abilities and entrepreneurial aspirations), 14 pillars and 28 variables

Sources: Authors' own elaboration based on reviewed references, Stanickova (2017b).

Commission, 2014), The Regional Lisbon Index (European Commission, 2010), Synthetic Index: Regional Perspective on the Lisbon Agenda (European Commission, 2007), or Composite Weighted Aggregate Index of Disparities (Melecký & Stanickova, 2015a). Stanickova, Melecký, and Poledníková (2011) reviewed their database analysis so as to explore EU cohesion and competitiveness, i.e., the ones in the most common areas that are the subject of EU evaluation and also the topic of the creation of CIs. Nowadays, one of the most representative EU indices is the RCI in its 2010, 2013 and 2016 editions (Table 3) – the RCI is also important in this paper in relation to linking the concept of competitiveness and resilience. Comparing RCI over time is complicated because each 2010, 2013 and 2016 edition incorporates improvements and slight modifications. These do not affect the overall structure of the RCI, but they limit the possibilities to measure change over time. The reasons for the changes are multiple: new indicators become available at the regional level, while others are not updated or no longer fit the statistical framework of the index. In addition, methodological improvements, especially between the first and the second RCI editions, and changes in NUTS regions make these comparisons complex. Nevertheless, the method has not changed substantially and there is a high degree of continuity in the list of indicators. Changes among the RCI editions are presented in Table 4, covering especially the disadvantages of this approach and the problems of the RCI time comparison which is not solved by using the methodology of RCI construction.

There are also CIs that do not represent an official EU approach (the approach of an international institution or country); however, these CIs evaluate the territories in relevant topics, e.g., Social Progress Index (Porter, Stern, & Green, 2016), Resilience Index Measurement and Analysis model (United Nations, 2016), the Organisation for Economic Co-operation and Development's (OECD) approach to quality of life and well-being evaluation (OECD, 2016), and others, as stated by Stanickova (2017b).

Different types of CIs can be used for uni-, bi- or multivariate analyses of data in any territorial level (country, region, district, municipality etc.), as Al Sharmin (2011) illustrates in his case study. On the other hand, CIs can send misleading messages to policy-makers if they are poorly constructed or interpreted, as evidenced by Nardo, Saisana, Saltelli, and Tarantola (2005). The construction of CIs is used in the universally accepted scientific rules for encoding. The definition type of a CI used in this paper was adopted from the European Commission, i.e., composite indicators are based on sub-indicators that have no common meaningful unit of measurement and there is no obvious way of weighting these sub-indicators (Saisana & Tarantola, 2002, p. 5). For this reason, when trying to suggest a construction for the CWIRR in this paper – the main focus is on choosing the relevant way and how to set the weights for each dimension of resilience. Weighting and aggregation systems have a crucial effect on the outcome of each composite index. There is not only one proper weighting method. Various functional forms for the underlying aggregation rules of a CI have been developed in the literature (OECD, 2008; Munda & Nardo, 2005), and in standard practice a CI can be considered as weighted linear aggregation rule applied to a set of variables (Munda & Nardo, 2005, p. 3), as shown in formal notation as follows:

$$CI = \sum_{i=1}^{N} w_i x_i, \tag{1}$$

$$s.t.$$

$$\sum_{i=1}^{N} w_i = 1 \quad \forall\, i = 1, \ldots, N, \tag{1a}$$

$$w_i \in < 0, 1 > \quad \forall\, i = 1, \ldots, N. \tag{1b}$$

Table 4. Structural information for regional competitiveness index (RCI) editions.

Edition	Data reference year	Geographical level/pillars	Indicators data sources
RCI 2010	Most recent data for all indicators, temporal range differs: individual years 2000, 2005, 2006, 2007, 2008 and 2009 and their variable combinations in averages	National: country level (institutions, macroeconomic stability, quality of primary and secondary education, technological readiness-part enterprises, not households)	Indicators: 81 candidate, 69 construct
		Regional: NUTS-2 level: all the other pillars; 268 NUTS-2 regions – EUROSTAT classification 2010	Databases: Special Eurobarometer; World Bank Worldwide Governance Indicators; EUROSTAT; OECD PISA; Nordregio; ISLA-Bocconi; European Cluster Observatory; OECD REGPAT; Thomson Reuters Web of Science & CWTS database
RCI 2013	Most recent data for all indicators, temporal range differs: individual years 2006, 2009, 2010 and 2011 and their variable combinations in averages	National: country level (institutions, macroeconomic stability, quality of primary and secondary education, technological readiness-part enterprises, not households)	Indicators: 80 candidate, 73 construct
		Regional: NUTS-2 level: all the other pillars; 273 NUTS-2 regions – EUROSTAT classification 2010	Databases: DG Regio project on QoG; Special Eurobarometer; World Bank Worldwide Governance Indicators; World Economic Forum – Global Competitiveness Index; EUROSTAT; OECD PISA; Nordregio; PBL NL Environmental Assessment Agency; ScienceMetrix based on Scopus data; OECD REGPAT; Cluster Observatory
RCI 2016	Most recent data for all indicators, temporal range differs: individual years 2009, 2011, 2013, 2014 and 2016 and their variable combinations in averages	National: country level (institutions, macroeconomic stability, quality of primary and secondary education, technological readiness-part enterprises, not households)	Indicators: 79 candidate, 74 construct
		Regional: NUTS-2 level: all the other pillars; 275 NUTS-2 regions – EUROSTAT classification 2013	Databases: Quality of Government Index by the Quality of Government Institute; Special Eurobarometer 325; World Bank Worldwide Governance Indicators; Worldbank – Doing Business; World Economic Forum GCI; EUROSTAT; Spiekermann & Wegener; TomTom RRG; EUROSTAT; EuroGeographics; OECD PISA; Nordregio; Regional Innovation Scoreboard; Science-Metrix based on Scopus data

Sources: Annoni and Kozovska (2010); Annoni and Dijkstra (2013); Annoni et al. (2017); authors' own analysis and elaboration (2018).

where $x_i = (x_1, \ldots, x_N)$ is a scale-adjusted variable; and $w_i = (w_1, \ldots, w_N)$ is a weight-attached to x_i. In this framework, a crucial issue is the concept of weight.

The evaluation of the criteria weights may be subjective, objective and integrated. For a summarized list of the most common weighting methods, see, for instance, OECD (2008) or Ginevičius and Podvezko (2004). The evaluation of criteria used in the construction of the CWIRR belongs to multiple-criteria evaluation problems which consist of a finite number of criteria and alternatives explicitly known at the beginning of the solution process. The multiple-criteria evaluation problem can be described by a matrix: $\mathbf{R} = \|r_{ij}\|$ $(\forall r_{ij}: i = 1, \ldots, p; j = 1, \ldots k)$ of the criteria significances $R_j \in \{R_1, \ldots, R_k\}$, characterizing the compared alternatives $A_i \in \{A_1, \ldots, A_p\}$. These significances r_{ij} may be statistical data or the estimates provided by experts. Subjective methods of weight determination are based on expert evaluation. There are numerous techniques for the subjective determination of the criteria weights (significances), including ranking or pairwise comparison. The objective approaches to calculating the criteria weights, such as the entropy method, evaluate the structure of the matrix **R** representing the values r_{ij}, while the values of the weights may change together with the values themselves. In this paper, the entropy determines the weights of r_{ij} presented by a factor score of factors of resilience extracted from factor analysis (FA) (evaluating criteria R_j) and EU-28 NUTS-2 regions (compared alternatives or variant A_i). For more information about the properties of entropy indices, see Bellù and Liberati (2006) or Zardari, Ahmed, Shirazi, and Yusop (2015) who describe the advantages and disadvantages of the weighting based on entropy. The entropy method is a measure of uncertainty in the information formulated using probability theory. It indicates that a broad distribution represents more uncertainty than the sharply peaked one (Deng, Yeh, & Willis, 2000). The method is based on information on alternatives and can be used only in the case of a finite number of alternatives. This method requires knowledge about the values of all the criteria for all variants in the matrix **R**. In the theory of information, entropy is the criterion of uncertainty posed by a discrete probability distribution p_i. This degree of uncertainty, based on Shannon (1948) and popularized, for example, by Karmeshu (2003), is as follows:

$$S(p_1, p_2, \ldots, p_n) = -\mathrm{c} \sum_{i=1}^{n} p_i \ln p_i, \tag{2}$$

where c is a positive constant. Equation (2) expresses entropy in a statistical concept, therefore entropy can be found as a probability distribution p_i and terms of entropy and probability are considered as synonyms. Suppose all p_i are equal, then for a given i, $p_i = \frac{1}{n}$ reaches a maximum value. Matrix **R** can determine the share of the ith variant (presented by an individual EU-28 NUTS-2 region) on the sum of the jth criteria (presented by extracted factors of resilience for each EU-28 NUTS-2 region) for all criteria p_{ij} from:

$$p_{ij} = \frac{r_{ij}}{\sum_{i=1}^{p} r_{ij}} \quad \forall i = 1, .., p \quad \forall j = 1, \ldots, k. \tag{3}$$

For the jth criterion, entropy (s_j) determines:

$$s_j = -c \sum_{i=1}^{p} p_{ij} \ln \mathrm{p}_{ij} \quad \forall j = 1, \ldots, k. \tag{4}$$

If suppose $c = \frac{1}{\ln p}$, then $0 \leq s_j \leq 1$ is guaranteed. The non-normalized entropy weight of the jth criteria (d_j) can be found:

$$d_j = 1 - s_j \quad \forall j = 1, \ldots, k, \tag{5}$$

while the respective normalized weights w_i are obtained from equation (6) where the sum of weights in each dimension is equal to 1:

$$w_j = \frac{d_j}{\sum_{j=1}^{k} d_j} \quad \forall j = 1, \ldots, k. \tag{6}$$

Based on general equation (1), we can finally calculate the CWIRR described in the procedure shown in Figure 1. In formal notation, the CWIRR designs:

$$CWIRR_r = \sum_{f=1}^{N} zw_f F_{f_r}, \tag{7}$$

$$s.t.$$

$$\sum_{f=1}^{N} zw_f = 1 \quad \forall f = 1, \ldots, N, \% \tag{7a}$$

where $CWIRR_r$ is the composite weighted index of regional resilience for the rth region; zw_f is the normalized weight of fth factor of resilience; F_{{f_{r} }}is the factor score of the fth factor of resilience for rth region; r is the EU-28 NUTS-2 region; $r \in$ {1 = AT11, … , 273 = UKN0}; and f is a factor of resilience. The dominating factors of resilience are extracted in the empirical part of the paper: $f \in$ {1 = CL, 2 = HC-SDS, 3 = LM, 4 = EP, 5 = ISR}.

REGIONAL RESILIENCE: EMPIRICAL EVIDENCE OF EU-28 NUTS-2 REGIONS

Generally, resilience can be defined as the status of the system in which its characterizing parameters tend to make the system economically resilient and, at the same time, capable of

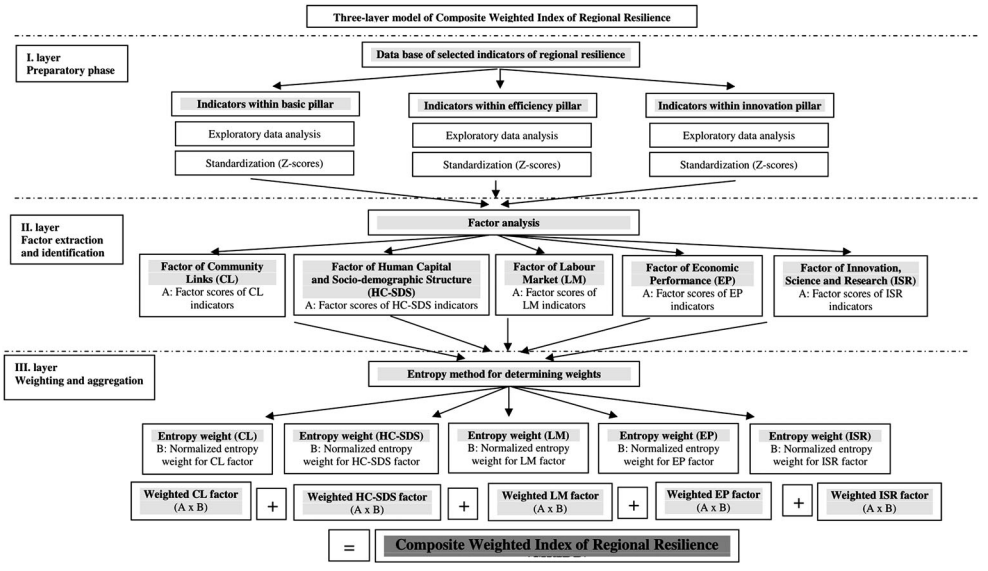

Figure 1. Construction of the composite weighted index of regional resilience (CWIRR). Source: Authors' own proposal and elaboration, 2017.

harmonic development and improvement with any changes in the external environment (Melecký, 2015). In social science literature reviews on resilience, perhaps the most traditional meaning of resilience is the ability of a regional economy to maintain a pre-existing state (typically assumed to be an equilibrium state) in the presence of some kinds of exogenous shocks (Stanickova, 2017b). Today, regions all over the world are facing pressures that are forcing them to rethink the impacts of policies aimed at competitiveness and integration into the global economy on their socio-spatial structures, following a period of entrepreneurial policies shaped by the notions of globalization and competition (Eraydin & Tasan-Kok, 2013). However, the existing assets of competitiveness can quickly be eroded since their effects may differ from place to place. More importantly, the reliance on global conditions and the dominance of deregulatory measures make regions vulnerable in economic terms. In these cases, a system can fail, leading to a major reduction or complete loss in performance with respect to some or all measures. Resources are then needed to restore a system's performance to its normal levels. Similarly, the performance of a system over time can be characterized as a path through the multidimensional space of performance measures. This characterization of system performance leads to a broader conceptualization of resilience and to the question: what are the main characteristics of regional resilience?

The resilience of regional economies is, thus, a valid topic for academic enquiry, not only in its own right but also because of its potential importance for informing policy-making. Only a thorough analysis involving multiple research dimensions from economic, environmental, institutional, social and political studies may assure a conceptual definition and a reliable and relevant comprehensive analysis of the regional resilience. This paper showed that the approach to CIs could be a perspective method for the evaluation of resilience because there is not only one correct method about how to create CIs and, thus, CIs can be employed, which is also the EU's case. Our own approach in the form of the EU-28 resilience index at the NUTS-2 regional level should allow one to compare the resilience of regions and measure the change in resilience over time in order to highlight clearly the strengths and weaknesses of regional economies so as to inform and address actions. The contribution of the authors' own concept to regional resilience measurement will be especially in the territorial extent of analysis (i.e., the EU-28 NUTS-2 regions), as well as the thematic extent (i.e., not only socioeconomic aspects of resilience but also institutional aspects of the knowledge-based economy, and also environmental factors).

Construction of the CWIRR is based on the procedure shown in Figure 1. The first step in the analysis is to find relevant indicators that can be used to measure regional resilience. In the first layer of the model, a method for the standardized variable (Z-score) is used. In the second step, FA is applied to factors defining resilience. In the second layer, exploratory FA for partial calculation of factor loadings (saturation) is used. Factor loadings present the correlation coefficients between the original variable and the extracted factor by principal component analysis (PCA) and show how much of the variability of the factor is explained. Internal data consistency within each pillar is, thus, verified by PCA. Among multivariate methods, PCA is particularly suitable for statistically summarizing data in a parsimonious way. The usefulness of PCA in composite development is easy to understand: each dimension in a composite is designed to describe a particular aspect of the latent phenomenon to be measured (the level of competitiveness in this case). As these aspects are not directly observable, they are measured by a set of observable indicators that, by definition, are related to the aspect which they are supposed to describe and, consequently, to each other. In an ideal situation, each dimension should show a unique, most relevant PCA component accounting for a large degree of the variability associated with the full set of indicators. Moreover, all the indicators should contribute roughly to the same extent and with the same orientation to the most relevant component.

In the third step, an entropy method is applied when using different weighting schemes for each resilience dimension (factor). In the last step, the final calculation of the CWIRR is made. This procedure is demonstrated by Nardo et al. (2005) and used in the construction of

aggregate synthetic indices in several empirical analysis of regional development (Melecký, 2015; Žižka, 2013).

In this paper, FA was applied to find relevant factors of resilience based on the used data set – indicators were divided into factors crucial for EU regional resilience and also competitiveness. PCA was applied to check the internal consistency of each resilience dimension. Five dominating factors were extracted: community links (CL), human capital and sociodemographic structure (HC-SDS), labour market (LM), economic performance (EP) and innovation, science and research (ISR). These factors explained 81.748% of the total variability of indicators, which can be considered as a very satisfactory result (for more information, see Table 5).

Table 6 shows the indicators and their relevant factors, which are also classified with respect to their importance as regards resilience, i.e., weights for each dimension are mentioned. Based on FA preliminary results, it is clear that indicators associated with each factor are relevant for its dimension of resilience; also, a number of indicators being balanced across the factors. Therefore, almost all the pillars, and the respective factors, show a clear, unique, underlying resilience dimension with a well-balanced contribution of each indicator within each pillar/factor. Based on the entropy method's results, it is evident that values of weights are also balanced across factors. The greatest impact on the overall regional resilience has a human capital and sociodemographic structure dimension, which is logical considering the importance of human capital and its manifestations in all economic areas.

Figure 2 illustrates via a cartogram the prime results for the CWIRR. The CWIRR curve closer to a value of 0 shows the NUTS-2 regions that are less resilient and resistant, for example, to crises. Conversely, a higher CWIRR and curve more distant from the centre presents NUTS-2 regions that are more resilient and resistant to crises and, thus, more competitive. There are obvious differences between traditionally developed and known less-developed NUTS-2 regions, which means that the results of the CWIRR are conclusive and relevant at this regional level. Exact values for the CWIRR for all EU-28 NUTS-2 regions are shown in Appendix A. For all evaluated regions in the reference period, CWIRR scores are marked by a traffic light method and highlighted through a conditional formatting feature, which makes it easy to spot the differences in the index scores. As marked in Appendix A, regions with the highest and higher values of the CWIRR mean a better level of resilience – the higher the value, the darker the green used. Regions with the lowest and lower values of the CWIRR mean a worse level of resilience – the lower the value, the lighter the red used.

The research on EU-28 NUTS-2 regions on their resilience to crisis, especially in line with competitiveness, is conducted within the theoretical and empirical framework of the paper. The purpose of this paper is the identification of economic crisis impacts on regional economies and the analysis of structural and functional determinants in regions. Therefore, we attempt to answer the question: why are some regions more resilient than others? and to identify the policies supporting economic resilience. The gaps and variation in regional resilience should give rise to a debate about to what extent these gaps are harmful to their national situation, and to what extent the internal variation can be remediated.

Based on the results of the CWIRR sub-indices (based on resilience dimensions), we can see in totality an increasing heterogeneity in the resilience of regions across domains with more regions having similar scores across reference periods in the first and second dimensions of the community links and human capital and sociodemographic structures. Resilience in the fifth domain of innovation, science and research shows the highest diversity across regions, suggesting the different levels of sophistication of regional economies. The results of the CWIRR sub-indices describe factors that are strictly necessary for the basic functioning of any regional economy and cover aspects such as an unskilled or low-skilled labour force, infrastructures, the quality of governance and public health, which are also important economic and social determinants. They also describe a socioeconomic environment more developed than the previous one, with a

Table 5. Total variance explained.

	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
Component	**Total**	**% of variance**	**Cumulative %**	**Total**	**% of variance**	**Cumulative %**	**Total**	**% of variance**	**Cumulative %**
1	12.052	50.217	50.217	12.052	50.217	50.217	4.555	18.977	18.977
2	2.569	10.703	60.920	2.569	10.703	60.920	4.203	17.513	36.490
3	1.897	7.905	68.825	1.897	7.905	68.825	4.086	17.026	53.516
4	1.678	6.992	75.817	1.678	6.992	75.817	3.560	14.832	68.348
5	1.423	5.931	81.748	1.423	5.931	81.748	3.216	13.400	81.748

Source: Authors' own elaboration and calculation in IBM SPSS Statistics 24, 2017.

Table 6. Results of factor analysis and the entropy method.

Factors	**CL**	**HC-SDS**	**LM**	**EP**	**ISR**	**Sum of normalized weights**
Indicators	GE, C, RL, MPA, RPA	HLE, CDDR, HDDR, PE, LL, AU	ER, LTUR, ESS, CCCE	LP, GVA, DI, GDP	TPA, GERD, HRST, HTP, ICT	
Number of indicators	5	6	4	4	5	
Weights	0.205	0.223	0.195	0.194	0.182	1.000

Source: Authors' own elaboration and calculation in IBM SPSS Statistics 24, 2017.

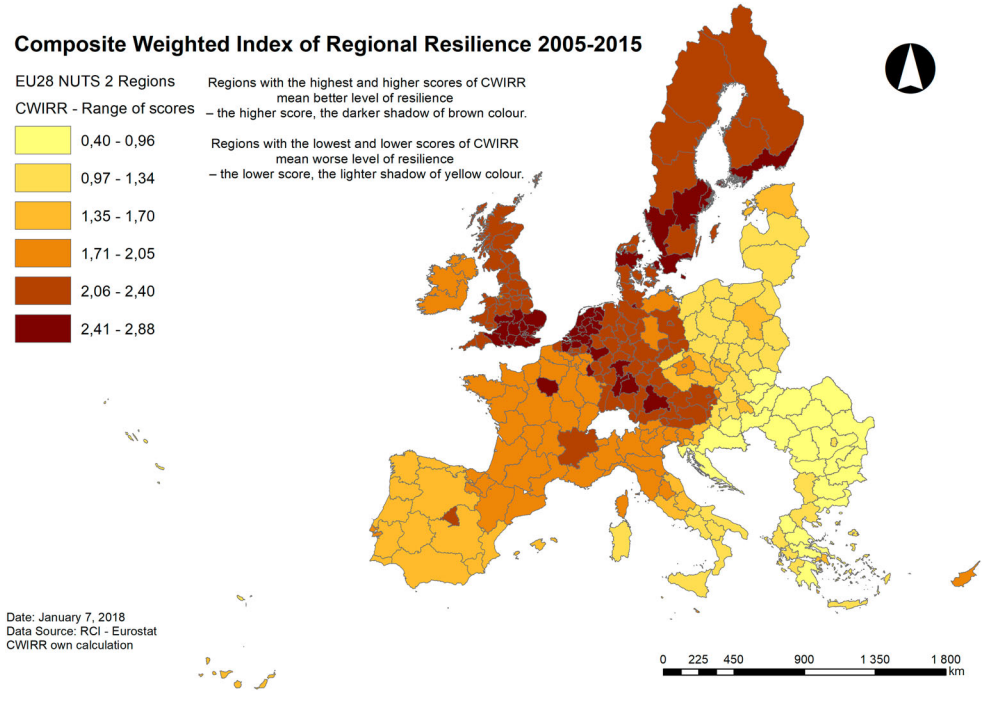

Figure 2. The composite weighted index of regional resilience (CWIRR), 2005–15. Source: Authors' own elaboration and visualization in ArcGIS 10.5.1, 2018.

potential skilled labour force and a more structured labour market. Lastly, the CWIRR sub-indices comprise all high-tech and innovation dimensions; a region scoring highly in these aspects is expected also to have the most resilient and competitive regional economy.

The CWIRR sub-indices also show the level of heterogeneity over time; a certain level of homogeneity across the EU is expected and the diversity suggests substantial differences in the sophistication of regional economies across and within countries. In many countries, the capital region is far more resilient than the other regions in the same country and many countries have highly heterogeneous scores for the CWIRR. The CWIRR shows a more polycentric pattern with strong capital and metropolitan regions in many parts of the EU. Some capital regions are surrounded by similarly resilient regions, but in many countries the regions neighbouring the capital are far less resilient. The substantial disparities within several countries also highlight the need for regional analysis and the limits of a purely national approach.

A division of the CWIRR results across the reference period shows clear differences between old and new member states, on the one hand, as well as differences between these two groups of the EU countries, on the other. A strong group of countries are Western European countries, and Scandinavian countries show the highest and higher CWIRR scores and a higher level of resilience. On the other hand, the southern circuit countries (Portugal, Spain, Italy and Greece) show the lowest and lower CWIRR scores with a lower level of resilience. Within the 'new' member states, differences are not so obvious; especially appreciable differences are in the capitals and catchment areas and other regions.

CONCLUSIONS

Despite the growing importance of resilience during the current period of global crisis, there is no generally accepted methodology for how the concept should be operationalized and measured

empirically. Similarly, there is no theory of regional economic resilience as such. Quantifying systems and regional resilience is a complex process, and scales for measuring resilience, at any level, do not currently exist. The resilience of regional economies is, thus, a valid topic for academic enquiry, not only in its own right but also because of its potential importance for informing policy-making. Only a thorough analysis involving multiple research dimensions from economic, environmental, institutional, social and political studies will assure a conceptual definition and a reliable and relevant comprehensive analysis of resilience.

This paper presented a framework for defining regional resilience and specifying quantitative measures of resilience that can serve as a base for comprehensive characterization of the socioeconomic problem to establish needs and priorities. Regional resilience is a much broader concept beyond the economic dimension. Well-defined and consistently applied quantifiable measures of resilience make it possible to carry out various kinds of comparative studies (e.g., to assess the effectiveness of various loss-reduction measures, such as structural problems), to determine why some regions are more resilient than others, and to assess changes in regions resilience over time. It is also reasonable to assume that the application of similar indices at the lower territorial level will require adaptation to national conditions and specifics. The applied framework in the form of the CWIRR makes it possible to assess and evaluate the contribution to the resilience of various activities implemented in the regions. The framework integrates measures into five dimension of regional resilience: community links (CL), human capital and sociodemographic structure (HC-SDS), labour market (LM), economic performance (EP) and innovation, science and research (ISR), all of which can be used to quantify measures of resilience for various types of regional systems which could serve for the establishment of the tasks required to achieve the required objectives. This framework makes it possible to assess and evaluate the contribution to resilience of the various activities implemented in regions, whether focusing on components, systems or organizations, with applications ranging from lifelines and building systems to the organizations that provide critical services. Because it takes a long time to change the regional characteristics that affect resilience-related outcomes, policies and strategies that are put in place after a region has experienced an economic shock are challenging activities, which is our future research orientation. In the framework of preliminary results, while a planning process that follows communicative rationality is to be used in shaping the planning process, the methods defined within the context of decision-making can be used to define the background or remove red tape in order to achieve no-regret conditions in the long term.

The ultimate objective of this paper is to propose the concept of a regional resilience index, which represents the initial concept and it is necessary to continually follow further the research. The designed index could help to disseminate information about and draw attention to the issue of resilience-building, to emphasize the point that not only countries but also nowadays regions need to build resilience so as to withstand their inherent economic vulnerability and to support the idea of integrated action for resilience-building. The construction of a regional resilience index could have important policy implications and be used to support the decision-making of regional policy-makers, especially for setting directions and justifying the choice of priorities for building the resilience of regions in future. The authors are aware that this is an ambitious goal currently. This baseline research points many future additional lines of inquiry, e.g., to drop the outliers – exceptionally advantaged regions could behave differently enough to mask the influences in other regions. The other orientation could be to use panel data methods that would allow us to use information about connections among observations and indicators, respectively sub-indices. Potentially, we could also recognize that some observations pertain to the same regions and some to the same years. In further research, we could differentiate between downturns before and after 2008/09, and update the database too etc. The authors' own concept will also vary greatly because of the approach used for index construction, i.e., when using the

quantitative methods such as advanced data envelopment analysis to analyse efficiency of resilience to exogenous shocks (such as the economic crises is).

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No potential conflict of interest was reported by the authors.

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APPENDIX A: SCORES FOR THE COMPOSITE WEIGHTED INDEX OF REGIONAL RESILIENCE (CWIRR) FOR EU-28 NUTS-2 REGIONS (IN ALPHABETICAL ORDER).

NUTS 2	CWIRR	NUTS 2	CWIRR	NUTS 2	CWIRR	NUTS 2	CWIRR	NUTS 2	CWIRR	NUTS 2	CWIRR	NUTS 2	CWIRR	NUTS 2	CWIRR
AT11	2.093	DE13	2.404	DK01	2.665	FR30	1.925	HU23	0.962	NL31	2.876	SE11	2.831	UKJ2	2.677
AT12	2.250	DE14	2.403	DK02	2.365	FR41	1.881	HU31	0.837	NL32	2.739	SE12	2.485	UKJ3	2.574
AT13	2.250	DE21	2.485	DK03	2.320	FR42	2.168	HU32	0.843	NL33	2.651	SE21	2.387	UKJ4	2.447
AT21	2.149	DE22	2.128	DK04	2.444	FR43	1.931	HU33	0.943	NL34	2.440	SE22	2.564	UKK1	2.610
AT22	2.120	DE23	2.184	DK05	2.297	FR51	1.951	IE01	1.777	NL41	2.613	SE23	2.555	UKK2	2.477
AT31	2.211	DE24	2.200	EE00	1.472	FR52	1.966	IE02	1.949	NL42	2.541	SE31	2.307	UKK3	2.156
AT32	2.285	DE25	2.349	ES11	1.677	FR53	1.873	ITC1	1.737	PL11	1.186	SE32	2.334	UKK4	2.346
AT33	2.289	DE26	2.311	ES12	1.680	FR61	1.951	ITC2	1.756	PL12	1.458	SE33	2.375	UKL1	2.094
AT34	2.307	DE27	2.253	ES13	1.700	FR62	2.033	ITC3	1.769	PL21	1.291	SI01	1.657	UKL2	2.388
BE10	2.365	DE30	2.302	ES21	2.003	FR63	1.885	ITC4	1.804	PL22	1.258	SI02	1.935	UKM2	2.311
BE21	2.435	DE41	2.302	ES22	1.892	FR71	2.108	ITD1	1.964	PL31	1.123	SK01	1.816	UKM3	2.158
BE22	2.402	DE42	2.302	ES23	1.745	FR72	1.777	ITD2	1.939	PL32	1.152	SK02	1.164	UKM5	2.352
BE23	2.440	DE50	2.346	ES24	1.783	FR81	1.828	ITD3	1.720	PL33	1.047	SK03	1.008	UKM6	2.125
BE24	2.365	DE60	2.575	ES30	2.152	FR82	1.907	ITD4	1.797	PL34	1.124	SK04	0.944	UKN0	1.950
BE25	2.362	DE71	2.571	ES41	1.652	FR83	1.755	ITD5	1.841	PL41	1.176	UKC1	2.103		
BE31	2.365	DE72	2.318	ES42	1.592	FR91	1.274	ITE1	1.717	PL42	1.141	UKC2	2.174		
BE32	1.825	DE73	2.253	ES43	1.485	FR92	1.321	ITE2	1.727	PL43	1.197	UKD1	2.202		
BE33	2.010	DE80	1.975	ES51	1.782	FR93	1.243	ITE3	1.625	PL51	1.211	UKD2	2.320		
BE34	1.919	DE91	2.276	ES52	1.643	FR94	1.211	ITE4	1.602	PL52	1.287	UKD3	2.326		
BE35	2.010	DE92	2.318	ES53	1.658	GR11	0.852	ITF1	1.503	PL61	1.069	UKD4	2.329		
BG31	0.396	DE93	2.183	ES61	1.441	GR12	1.038	ITF2	1.285	PL62	1.130	UKD5	2.049		
BG32	0.660	DE94	2.174	ES62	1.584	GR13	0.859	ITF3	1.033	PL63	1.274	UKE1	2.117		
BG33	0.732	DEA1	2.365	ES63	1.385	GR14	0.959	ITF4	1.121	PT11	1.470	UKE2	2.392		
BG34	0.589	DEA2	2.489	ES64	1.434	GR21	1.047	ITF5	1.210	PT15	1.535	UKE3	2.177		
BG41	1.085	DEA3	2.276	ES70	1.508	GR22	1.154	ITF6	1.026	PT16	1.525	UKE4	2.250		
BG42	0.752	DEA4	2.273	FI13	2.161	GR23	0.995	ITG1	1.034	PT17	1.805	UKF1	2.401		
CY00	1.802	DEA5	2.243	FI18	2.485	GR24	0.898	ITG2	1.341	PT18	1.531	UKF2	2.551		
CZ01	1.895	DEB1	2.285	FI19	2.266	GR25	0.917	LT00	1.068	PT20	1.331	UKF3	2.360		
CZ02	1.895	DEB2	2.229	FI1A	2.161	GR30	1.529	LU00	2.566	PT30	1.325	UKG1	2.472		
CZ03	1.617	DEB3	2.336	FI20	2.470	GR41	1.084	LV00	1.059	RO11	0.792	UKG2	2.327		
CZ04	1.315	DEC0	2.180	FR10	2.465	GR42	1.158	MT00	1.782	RO12	0.720	UKG3	2.226		
CZ05	1.598	DED1	2.102	FR21	1.749	GR43	1.139	NL11	2.534	RO21	0.623	UKH1	2.442		
CZ06	1.585	DED2	2.204	FR22	1.848	HR03	0.932	NL12	2.447	RO22	0.549	UKH2	2.617		
CZ07	1.449	DED3	2.209	FR23	1.828	HR04	0.905	NL13	2.470	RO31	0.669	UKH3	2.617		
CZ08	1.445	DEE0	2.052	FR24	1.953	HU10	1.362	NL21	2.543	RO32	1.304	UKI1	2.617		
DE11	2.496	DEF0	2.222	FR25	1.821	HU21	1.129	NL22	2.602	RO41	0.717	UKI2	2.617		
DE12	2.486	DEG0	2.240	FR26	1.830	HU22	1.211	NL23	2.739	RO42	0.696	UKJ1	2.773		

Source: Authors' own elaboration and calculation, 2017.